Ecosystem Dynamics Under Changing Climates

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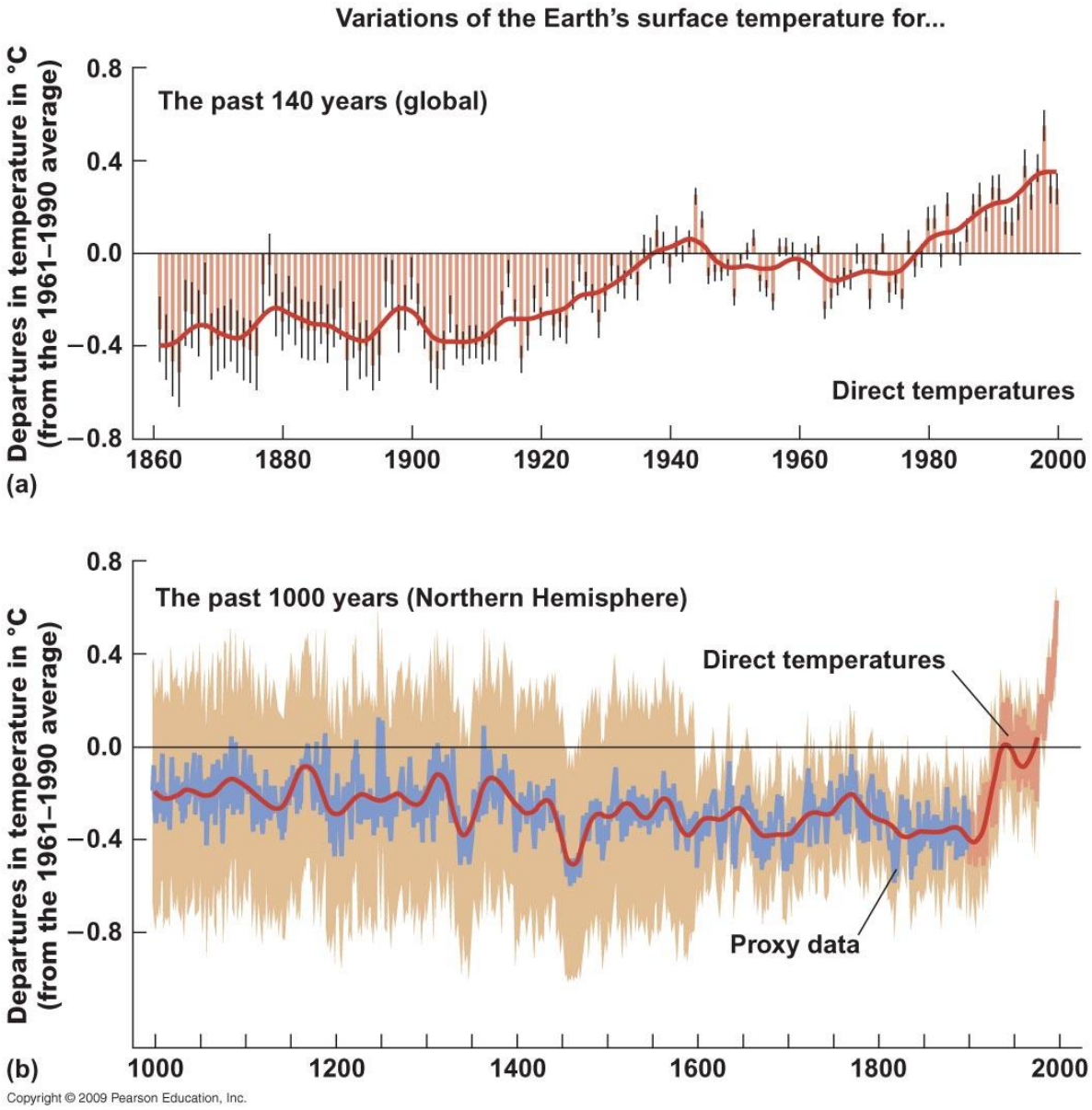
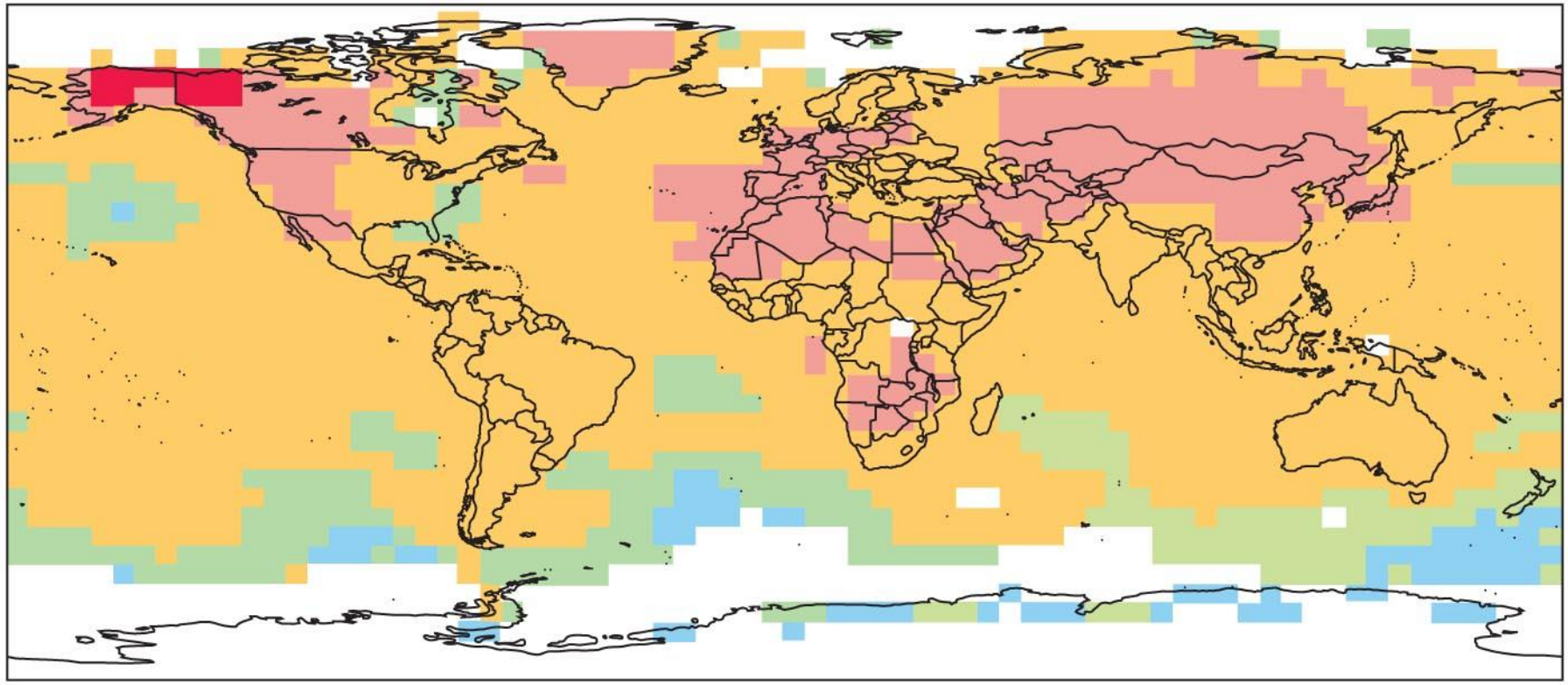
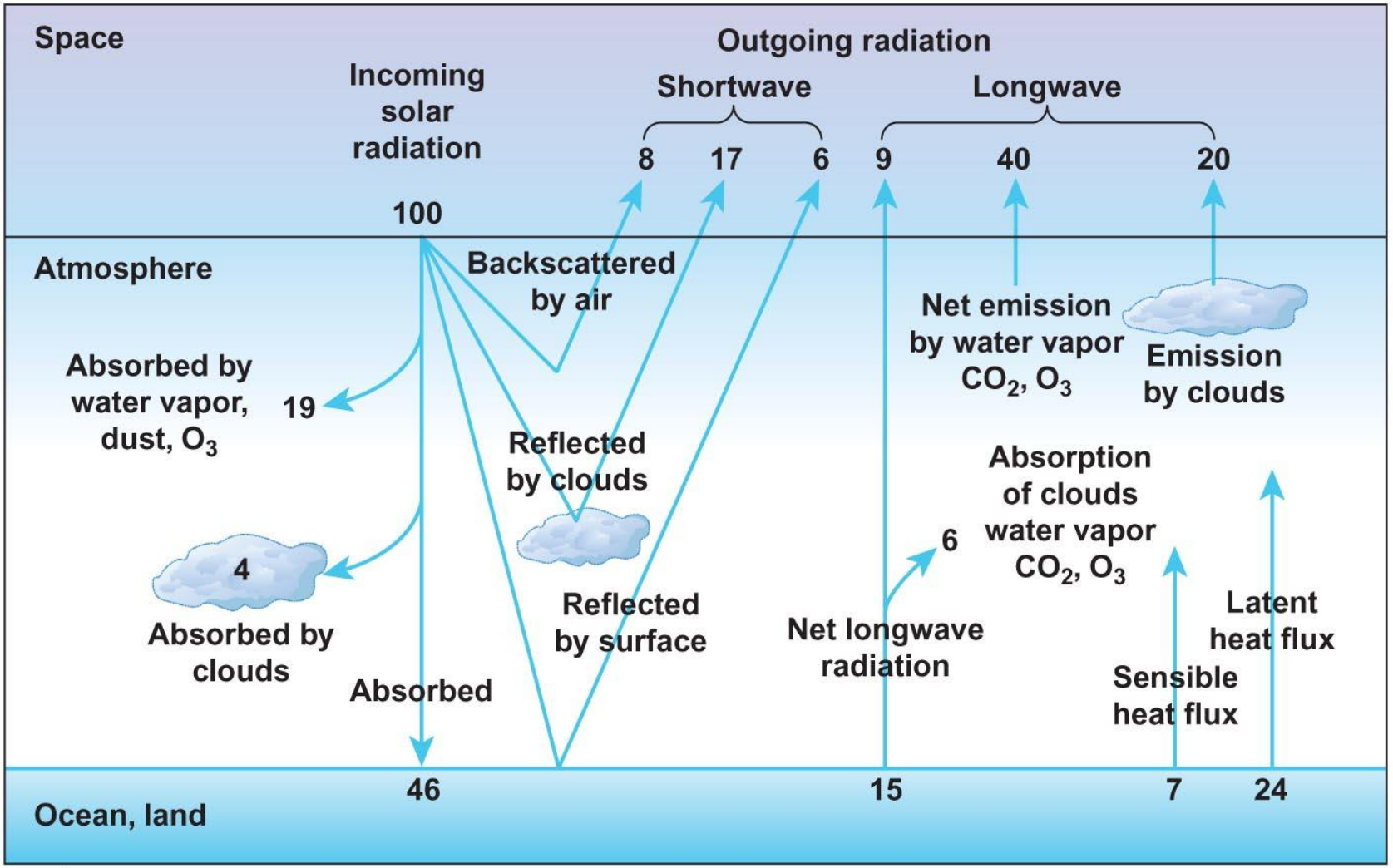


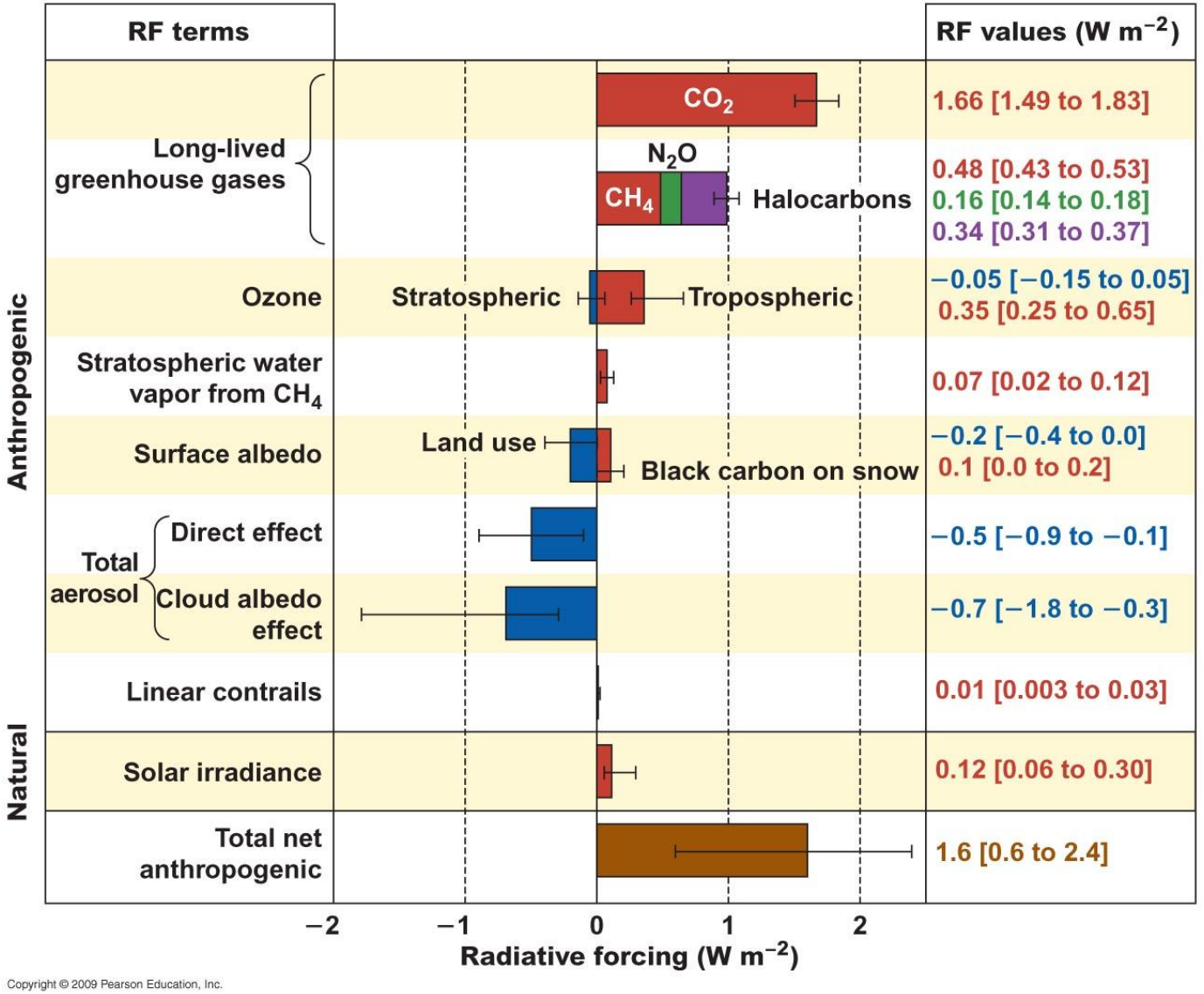
Temperatures are expressed as deviations from the 1961-1990 average



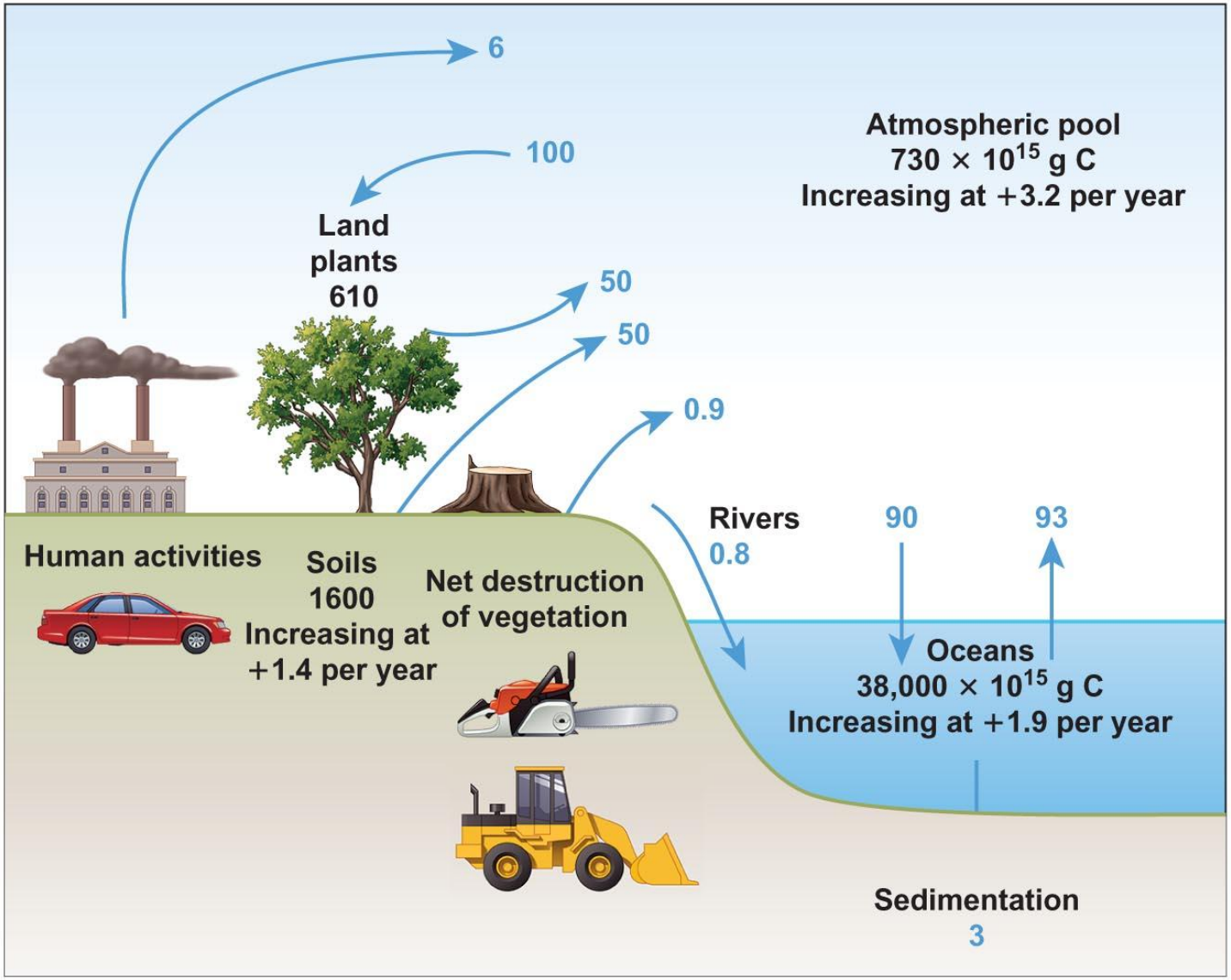
The greatest temperature increases have occurred in NW North America (red) and the pink areas on the map



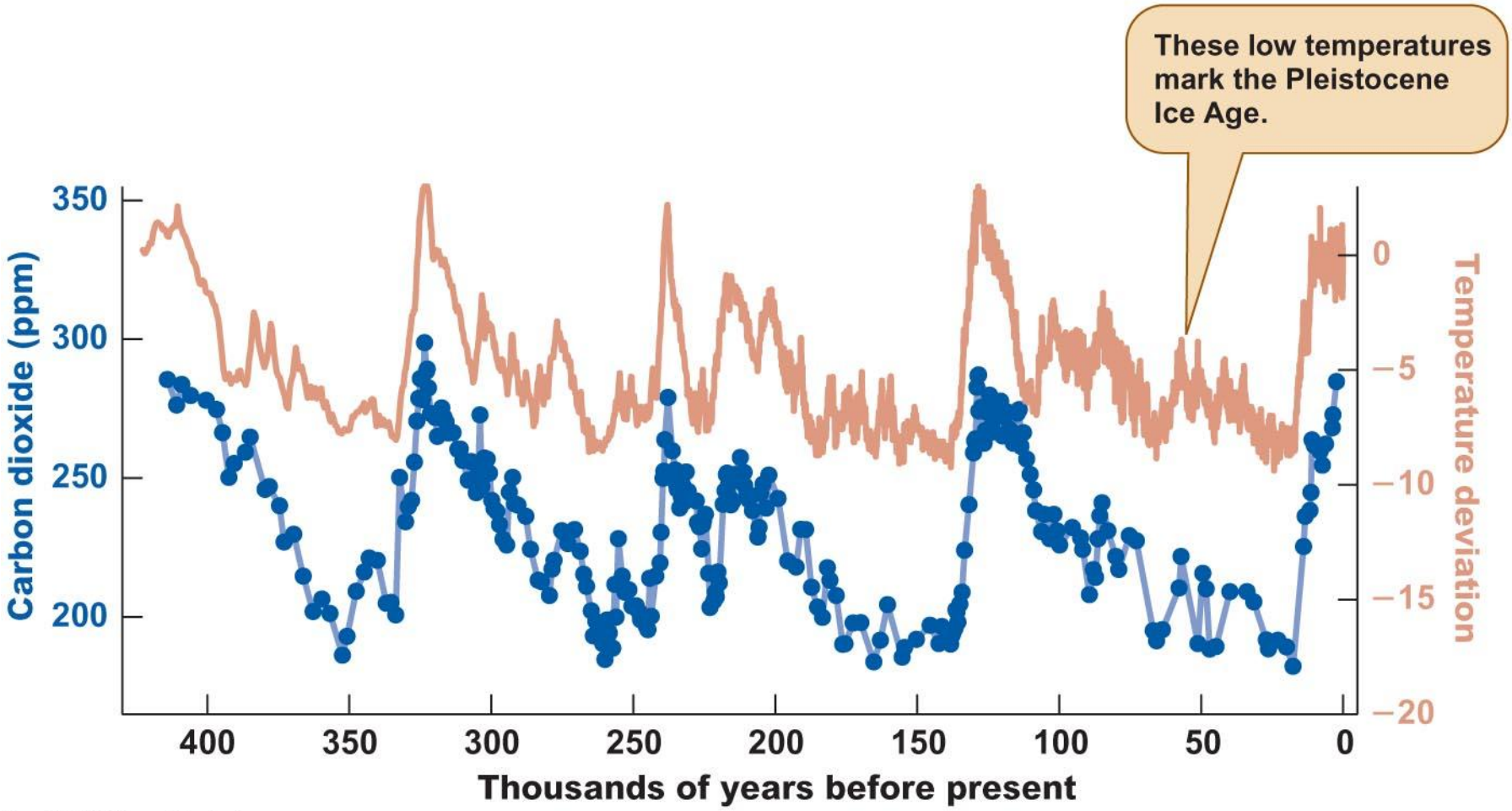
More greenhouse gas in the atmosphere means less longwave radiation emitted to space – thus warming the Earth



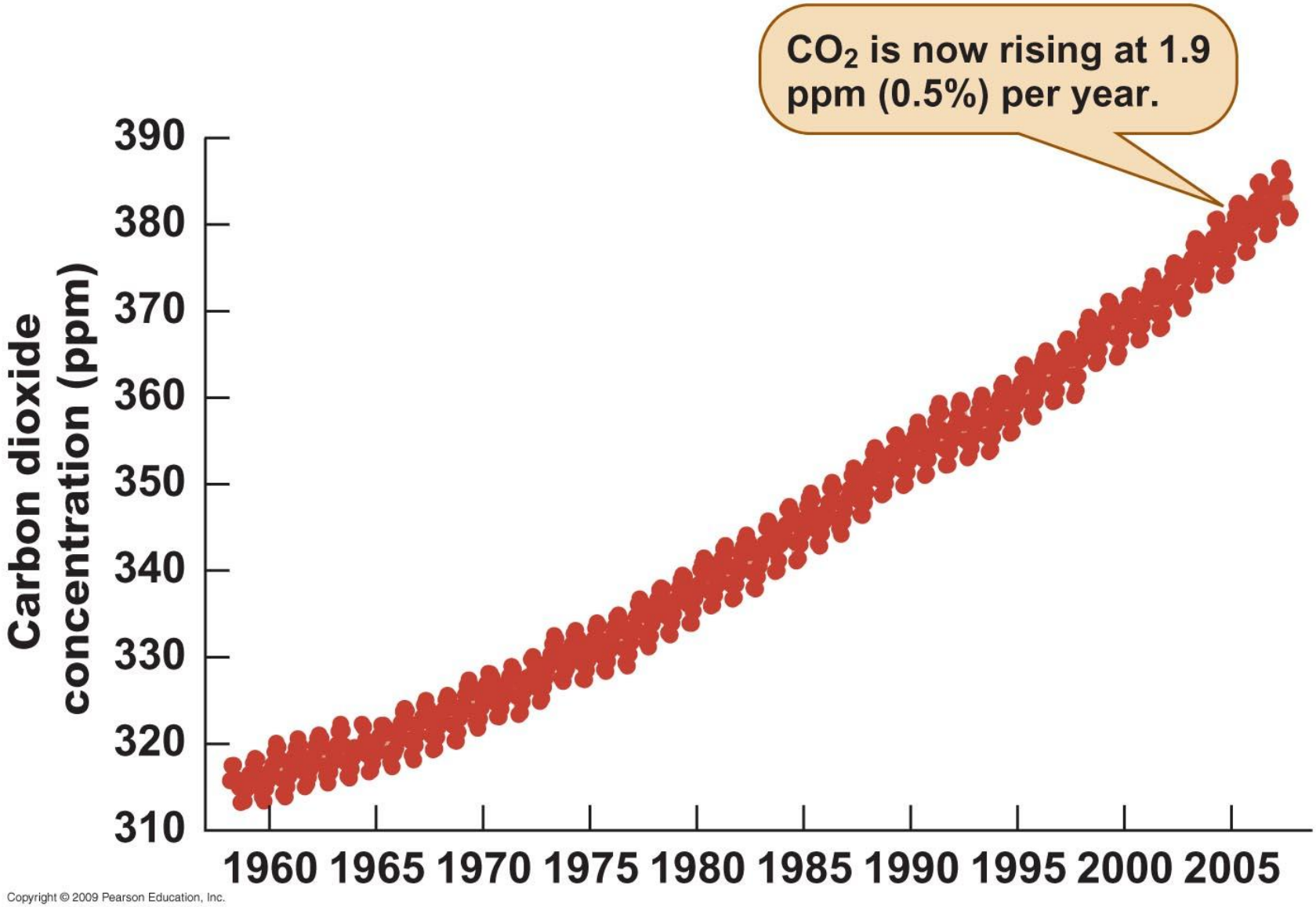
CO_2 is the most important greenhouse gas – it causes the most heating (RF)

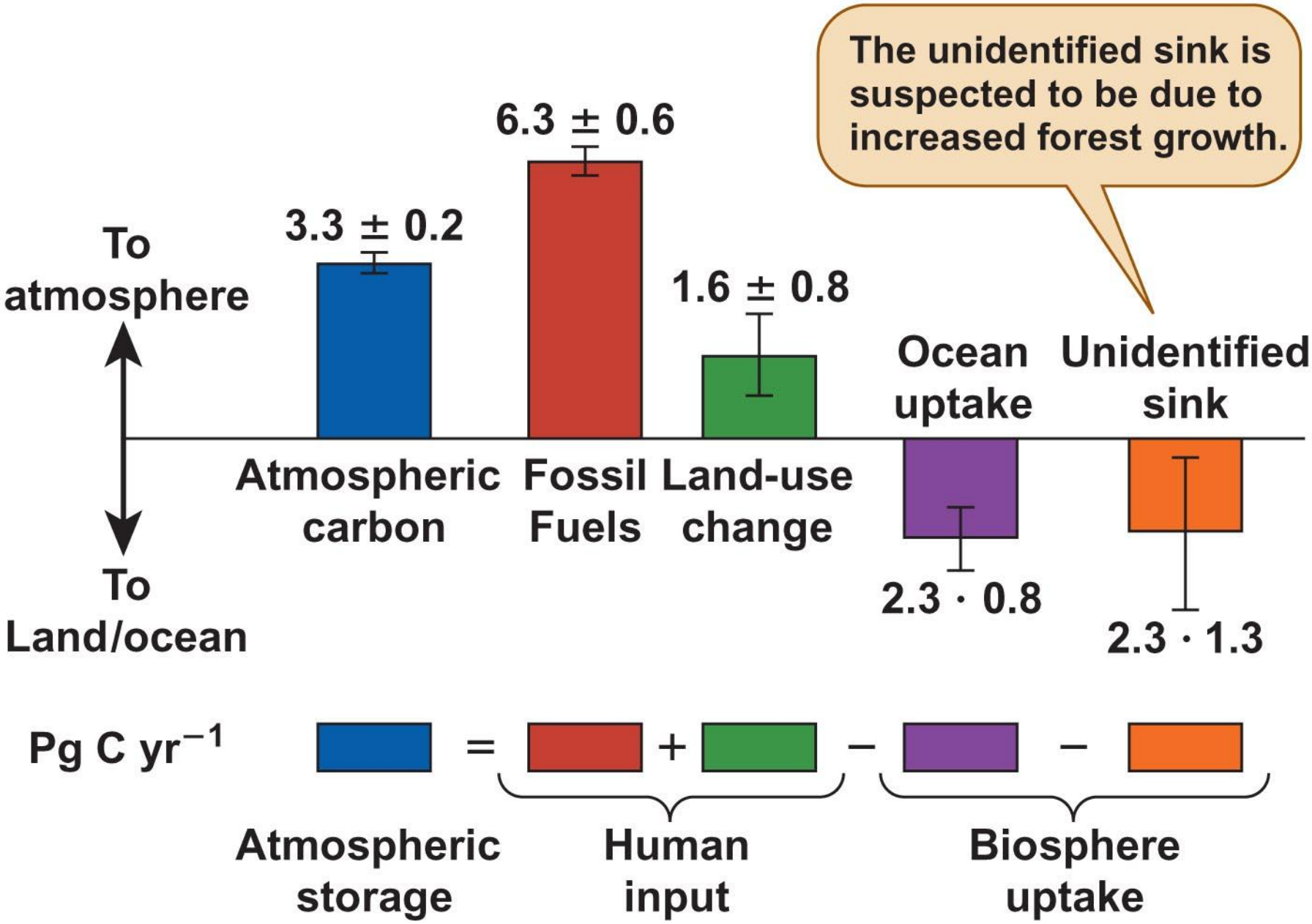


The carbon cycle – mostly in balance except for human activities



CO_2 concentration and global temperature are highly correlated





Observed Biological Responses to Recent Thermal Change

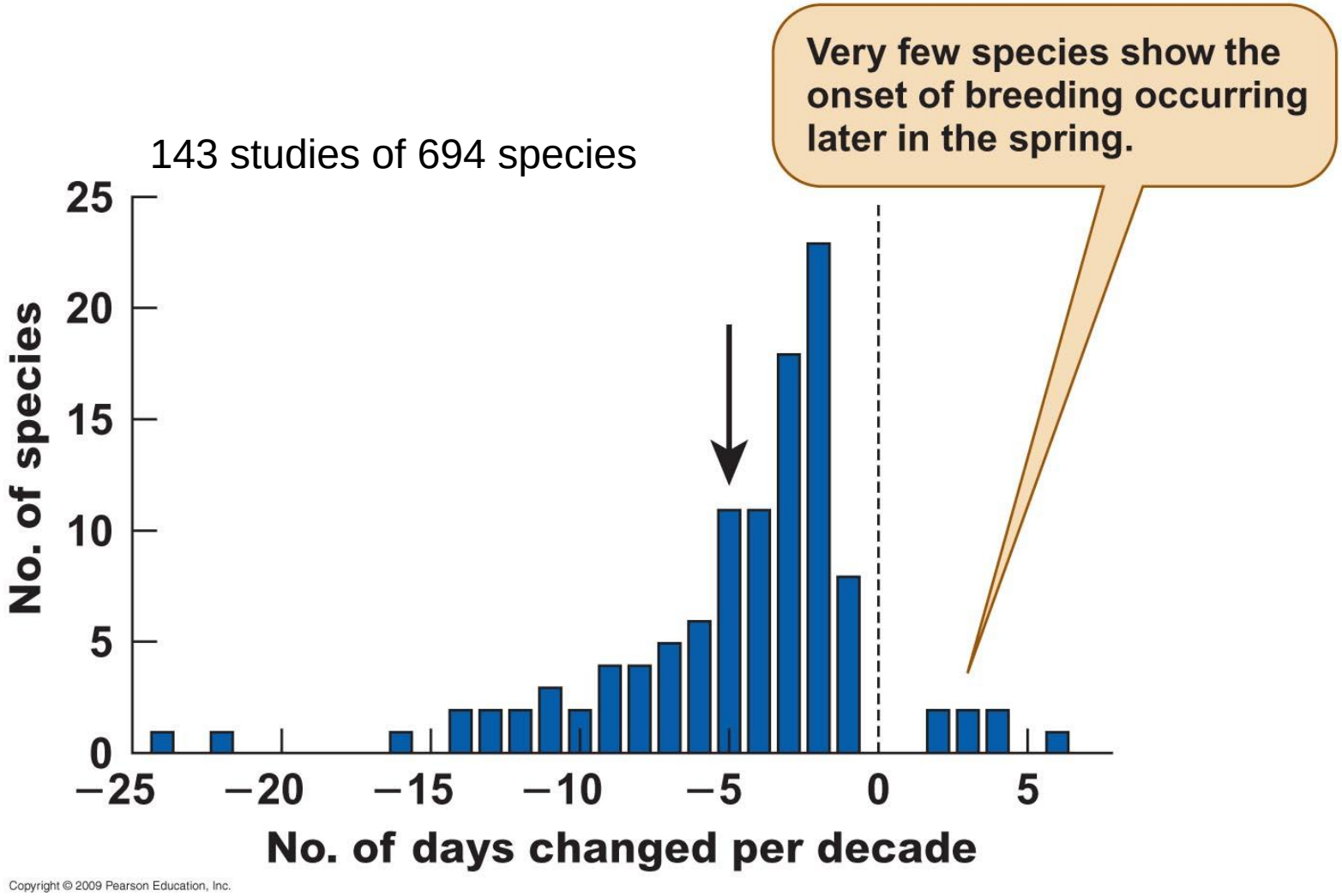
- Shifts in phenology – earlier in spring
- Shifts in geographic range – northward and upward
- Disruptions of species interactions
- Changes in plant growth – is more better?

Shifts in Phenology
(timing of biological events)

Timing of migration
Timing of nesting by birds
Timing of hatching – birds, insects

143 studies of 694 species

- earlier migrations
- earlier nesting
- earlier hatching

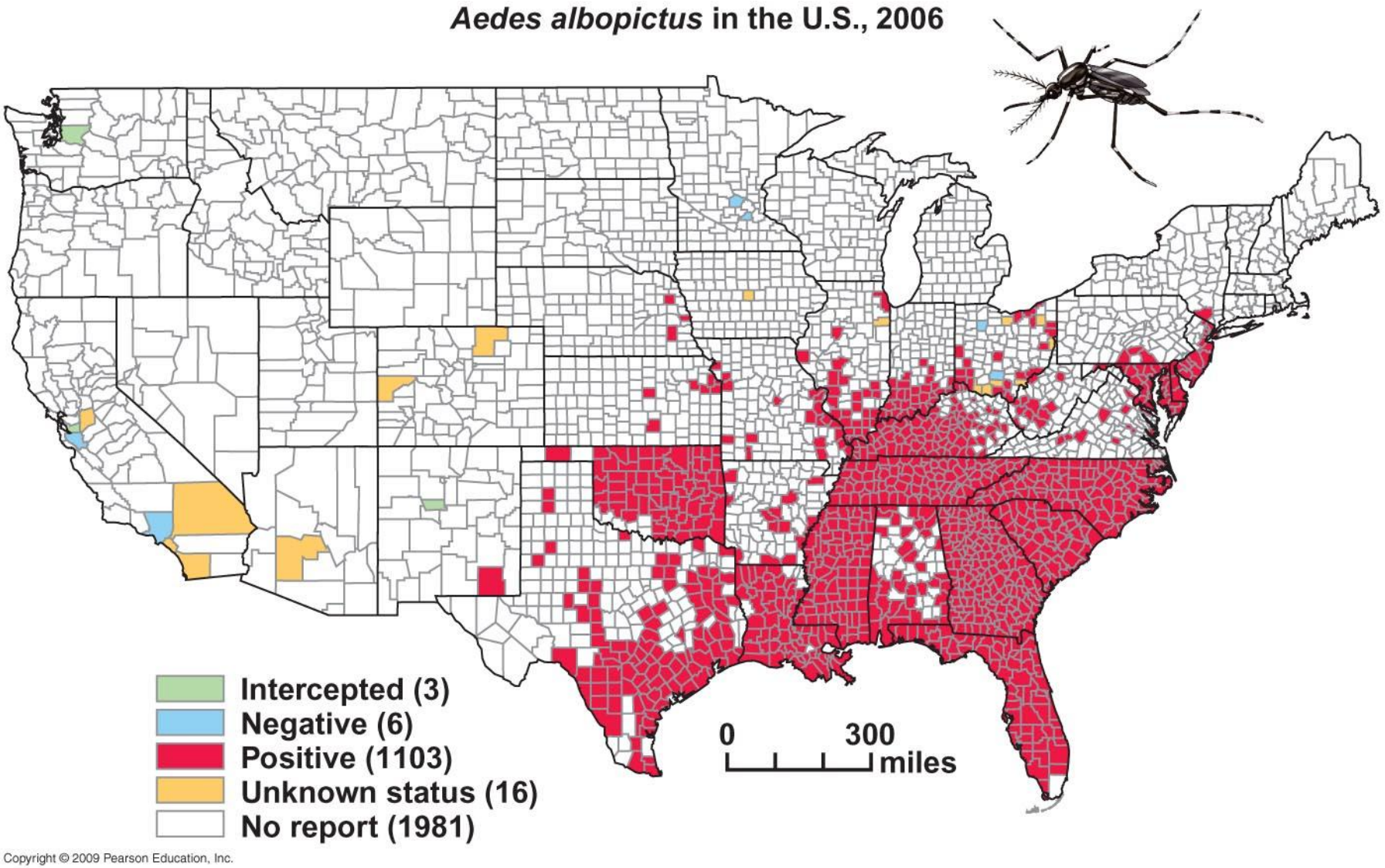


In plants and animals that have shown a change in life history events, the average change has been about five days earlier per decade

Shifts in Geographic Range

More introduced species

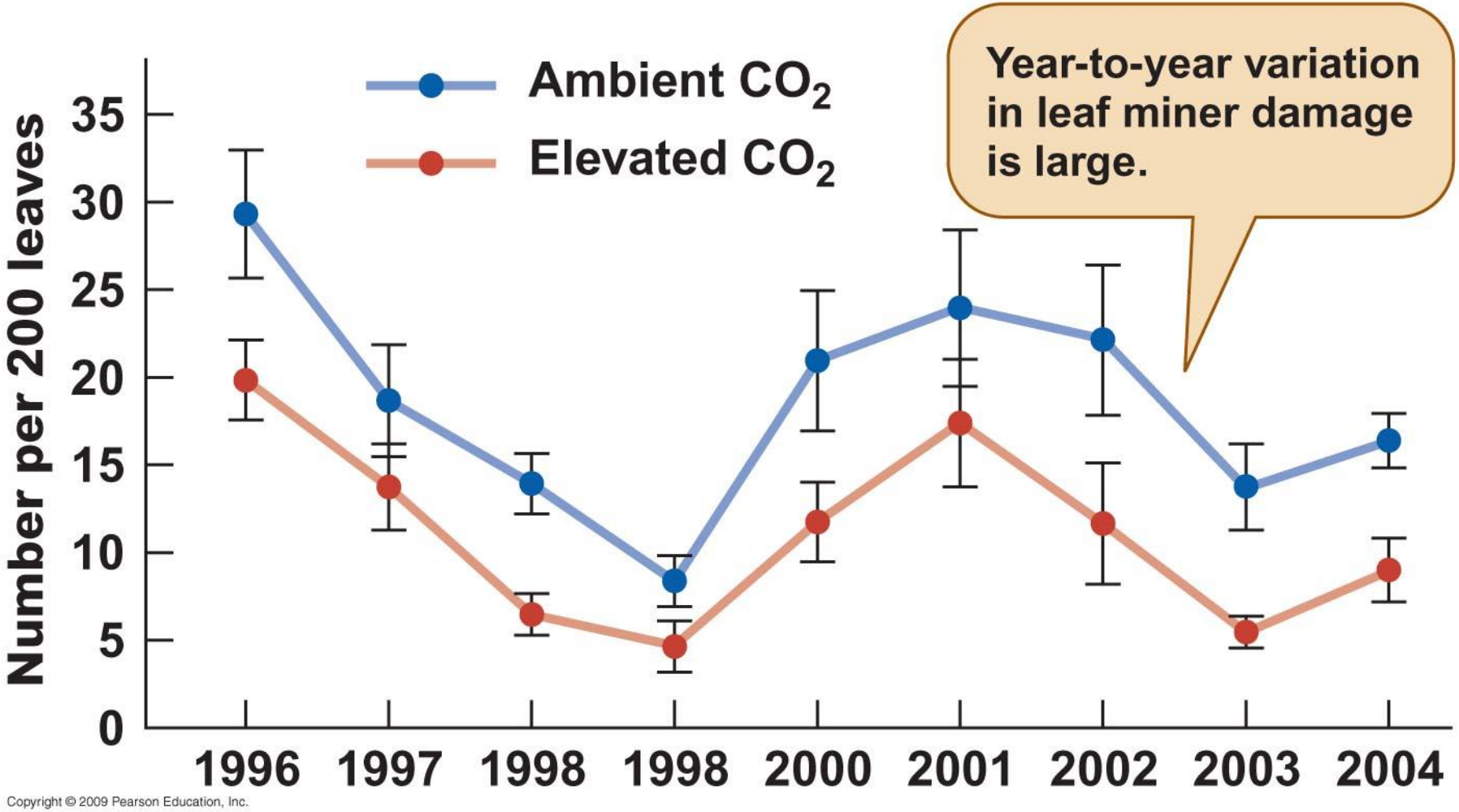
- *Aedes albopictus*



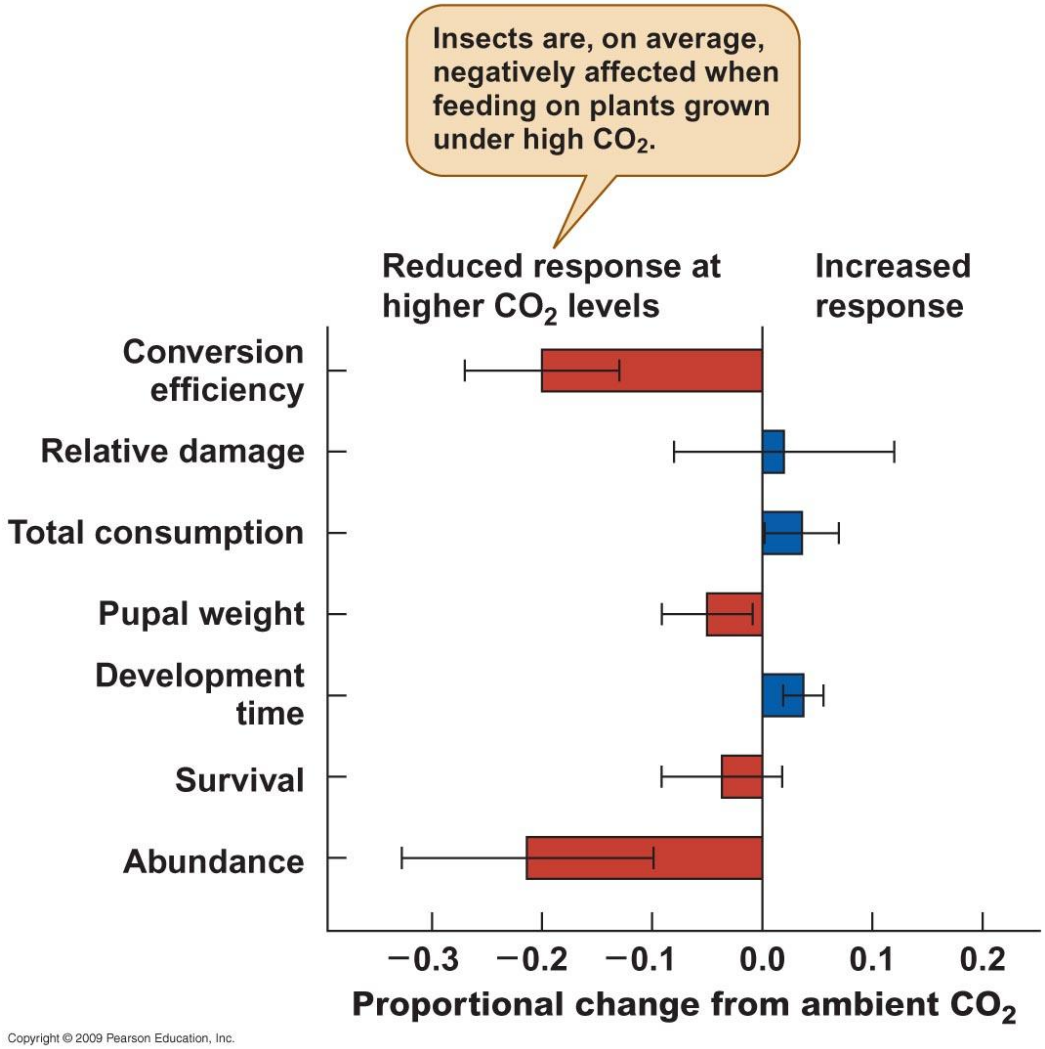
Colonization by the Asian tiger mosquito – vector for Dengue, West-Nile Virus, Yellow fever, etc.

Disruptions of Ecological Interactions

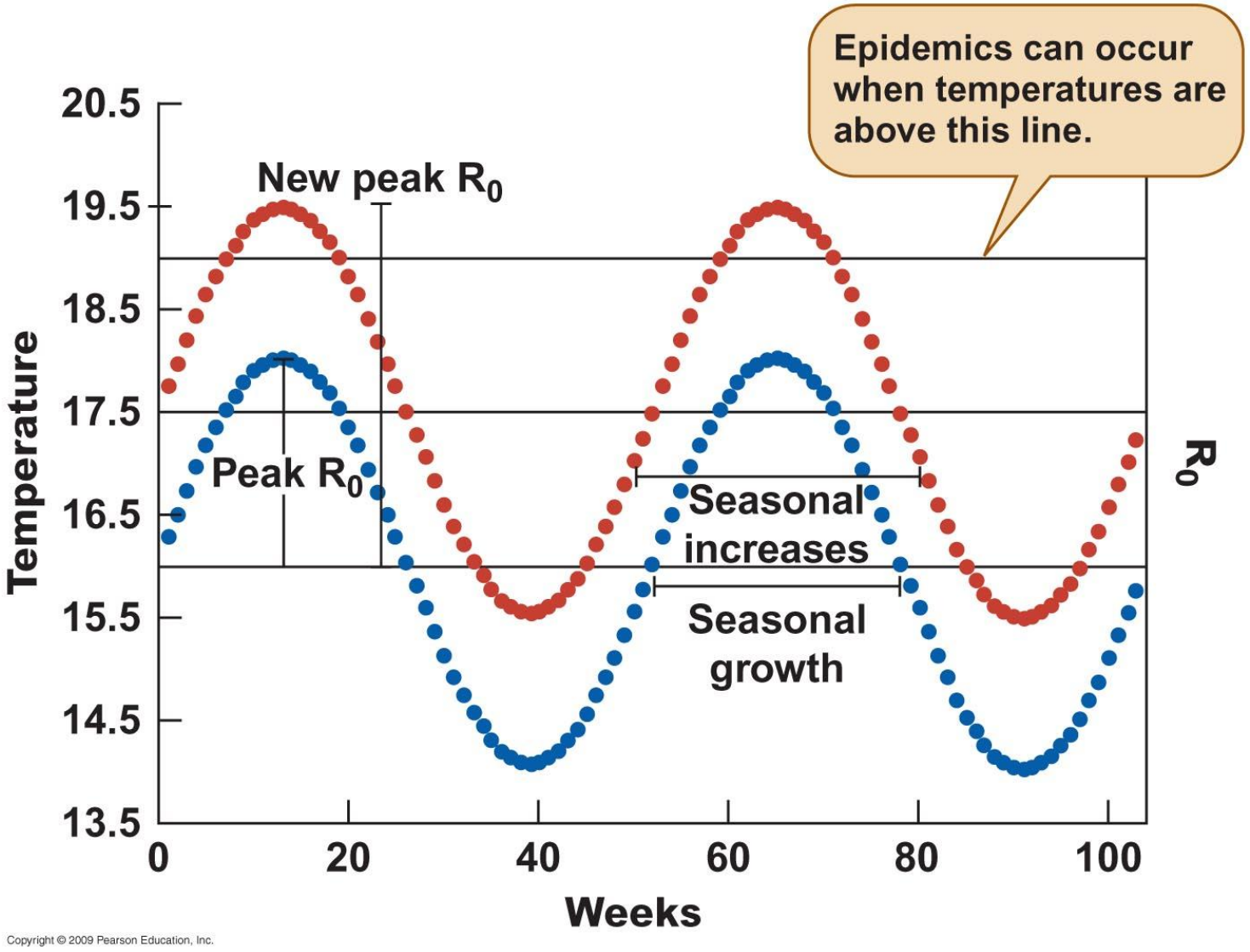
- Changes in food plants – leaf eaters on oak
- Disease susceptibility – pathogen/host interaction



Fewer leaf eaters on leaves of myrtle oak in Florida grown at double the ambient CO_2 concentration.



Lower nitrogen and more tannins in plants grown under enhanced CO_2 conditions means poorer growth in herbivorous insects feeding on them



A 1.5 ° C increase in temperature increases pathogen population growth (R_0) and season of host susceptibility in a model pathogen.

Changes in Primary Productivity

Individual plant responses

- C_3 v C_4 plants

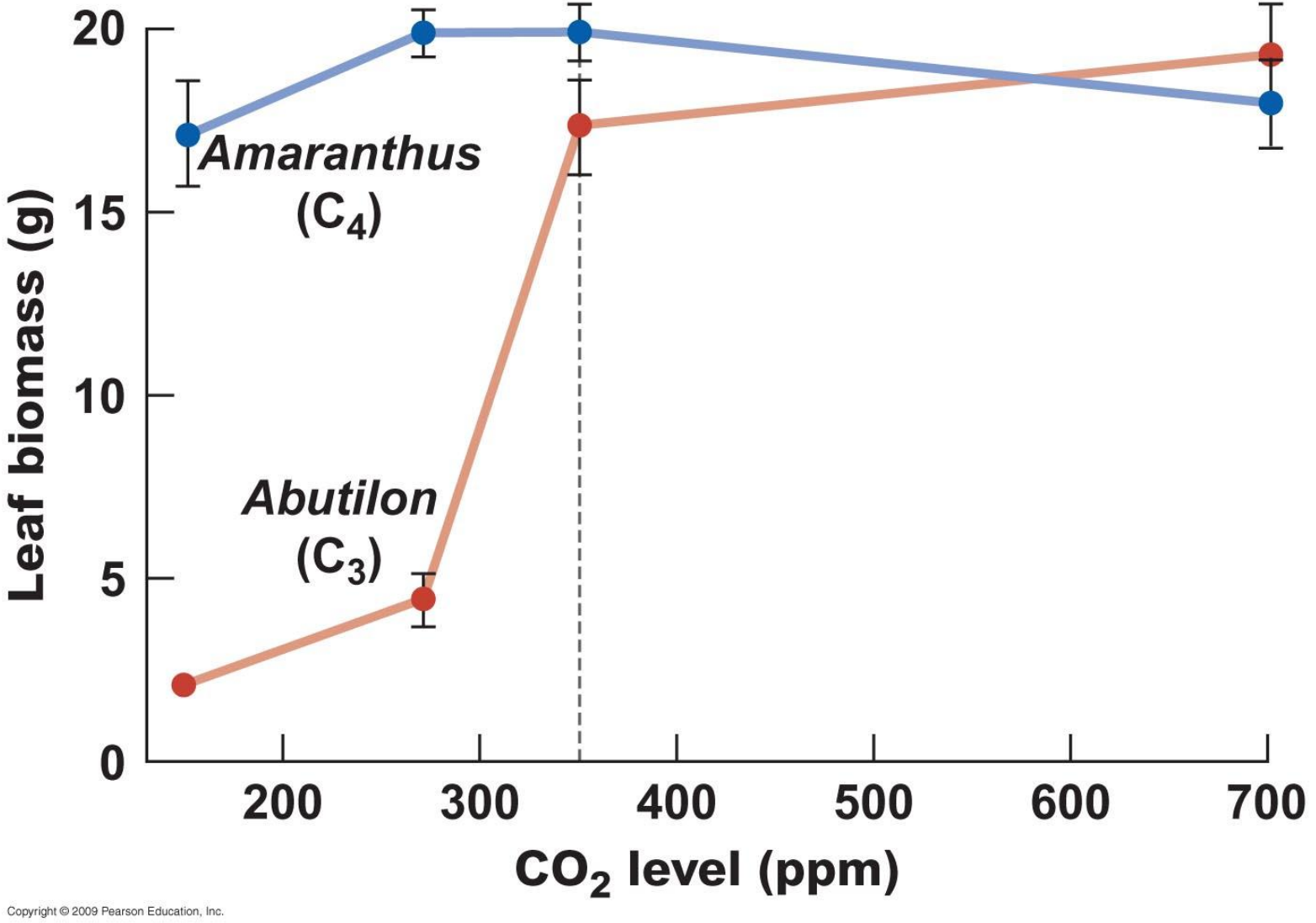
Plant community responses

- arctic plants – complex response
- tropical tree growth – increasing
- global net primary production – mixed response

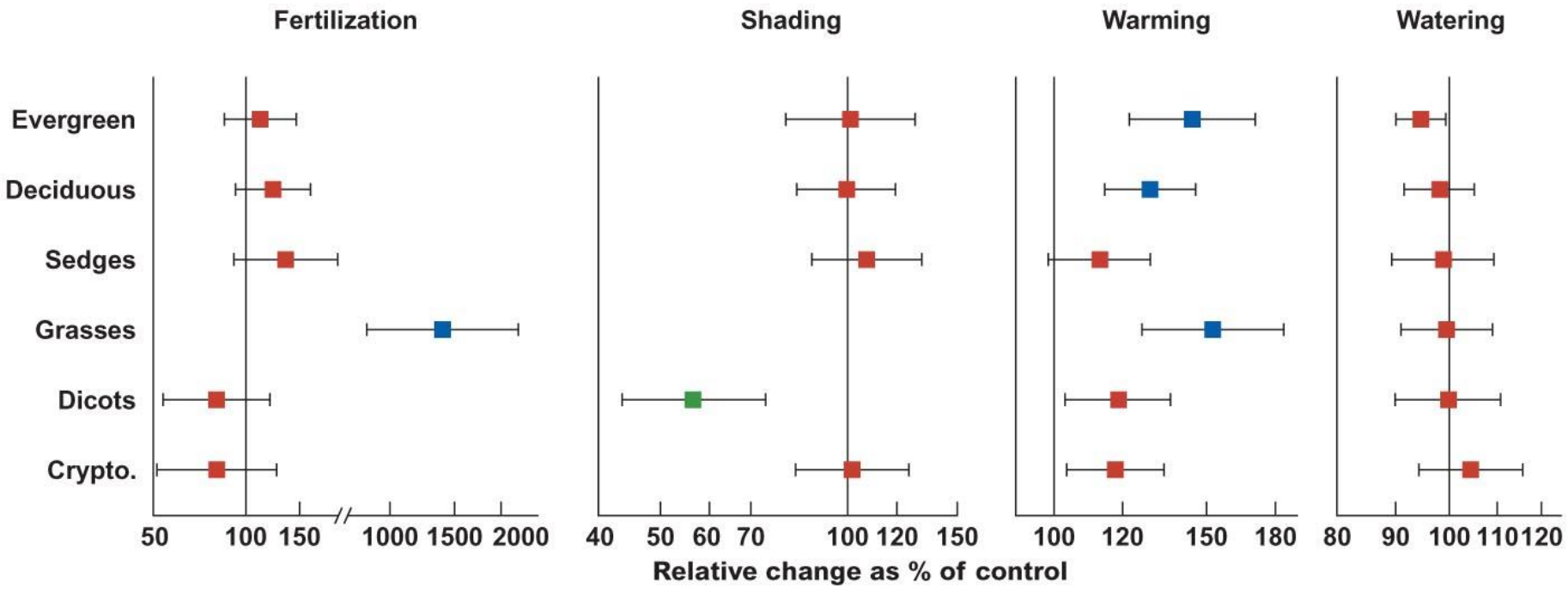
(a)

(b)

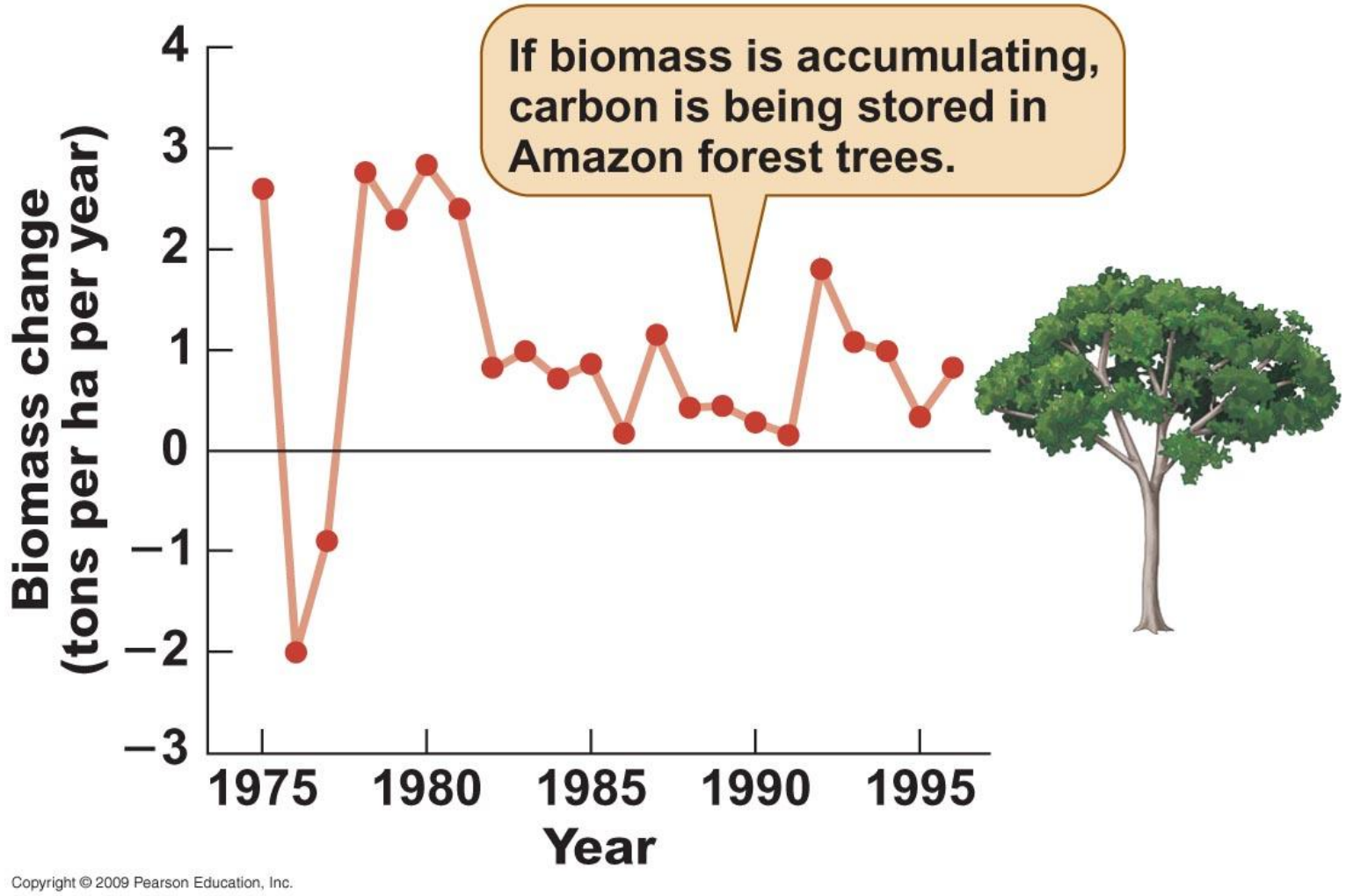
Aspen FACE experiment (Wisconsin): twelve 30 m diameter rings in which the CO_2 concentration can be controlled



Response of annual C_3 and C_4 plants to four CO_2 levels in a greenhouse

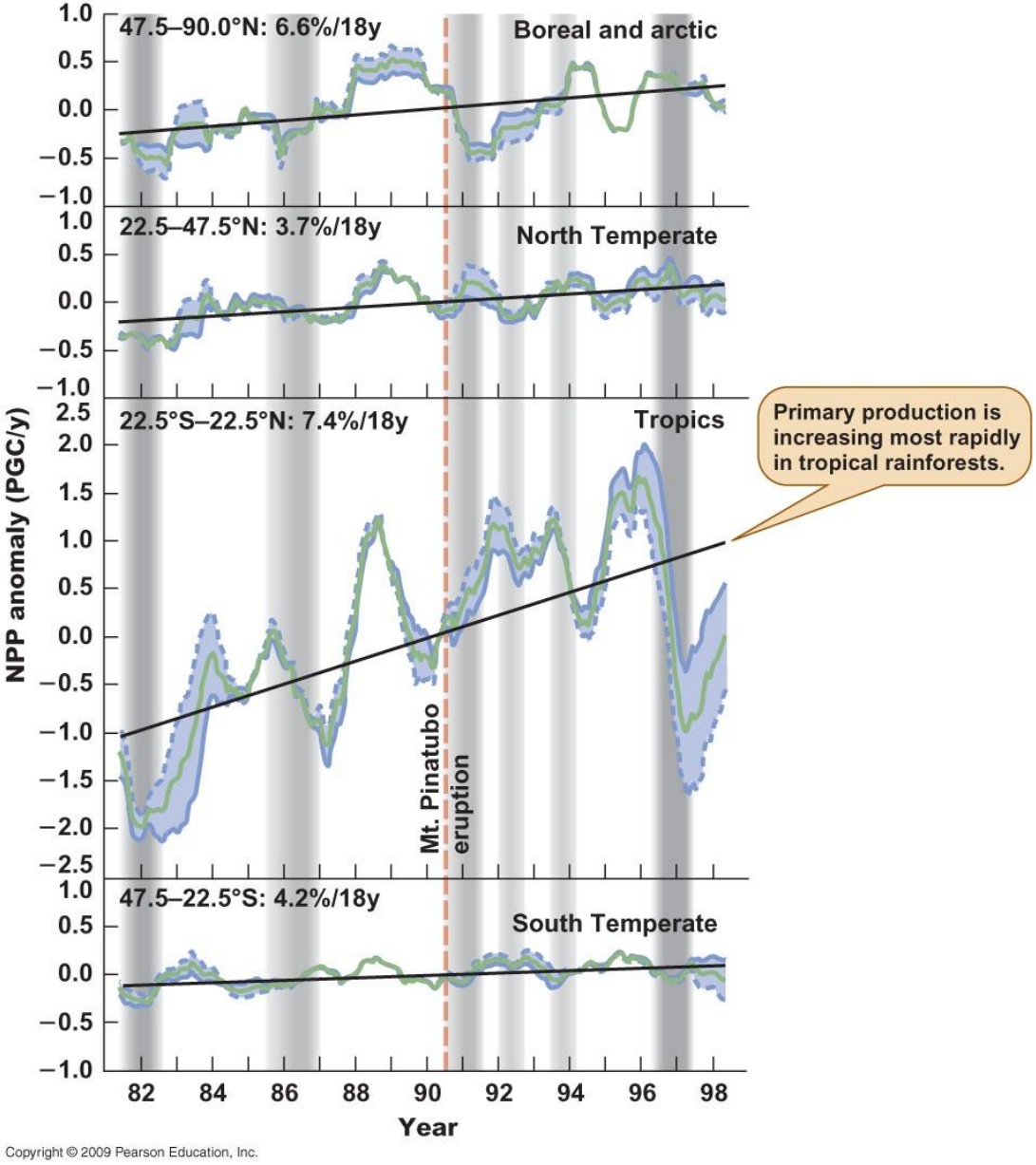


Plant community responses to CO_2: Biomass response of Arctic plant communities to fertilization, shading, warming in greenhouses in summer, and watering (data from 36 experiments) **Increased CO_2 alone has little effect on this plant community**



Annual above-ground biomass change in 97 Amazonian forest plots. Biomass increased in almost every year.

Changes in global net primary production from satellite data 1982-1997. Increases are greatest in Amazonia and northern high latitudes.

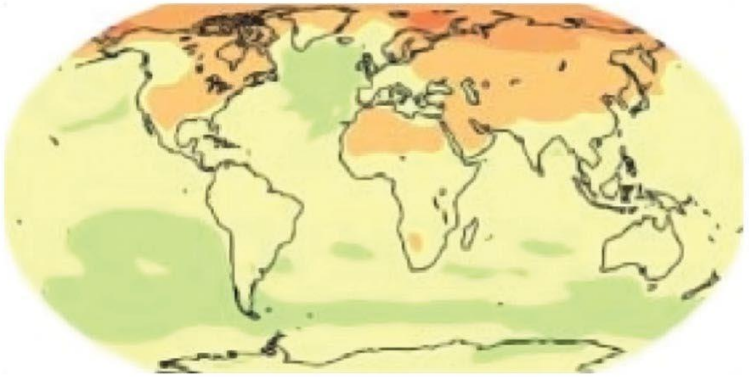


Some Predicted Changes Due to Climate Warming

Changes in geographic distribution

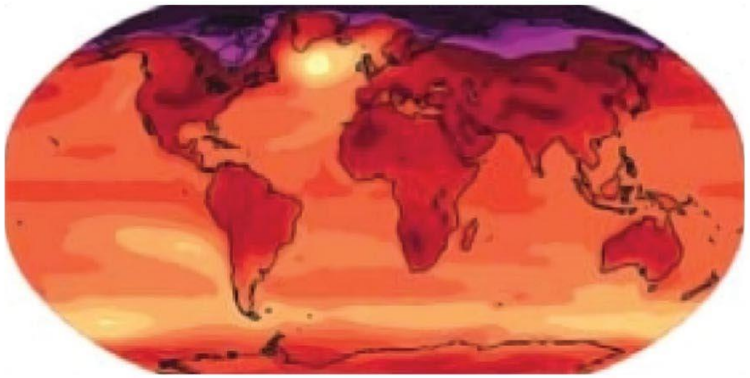
Changes in sea level

2020-2029



2020–2029

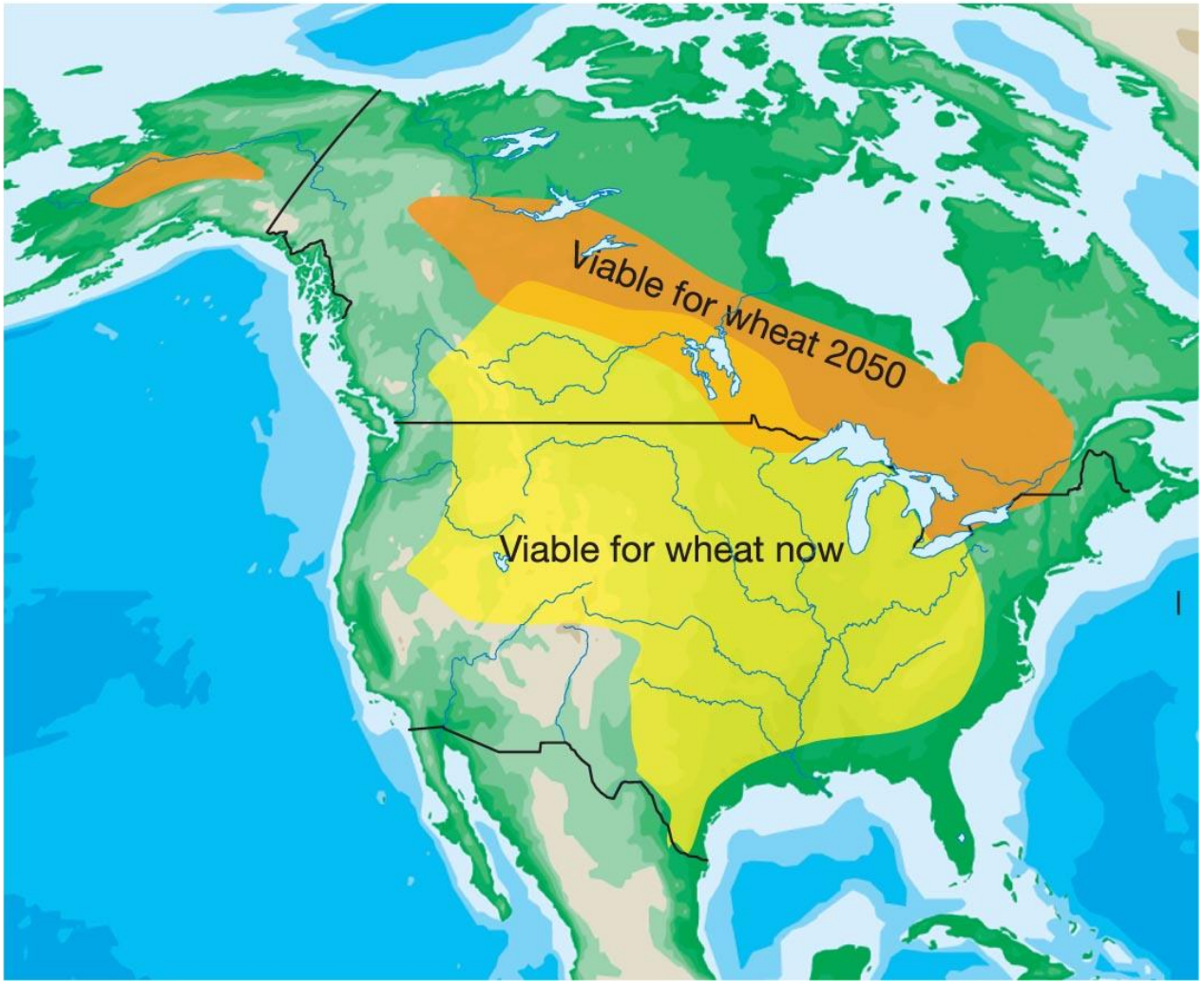
2090-2099



2090–2099

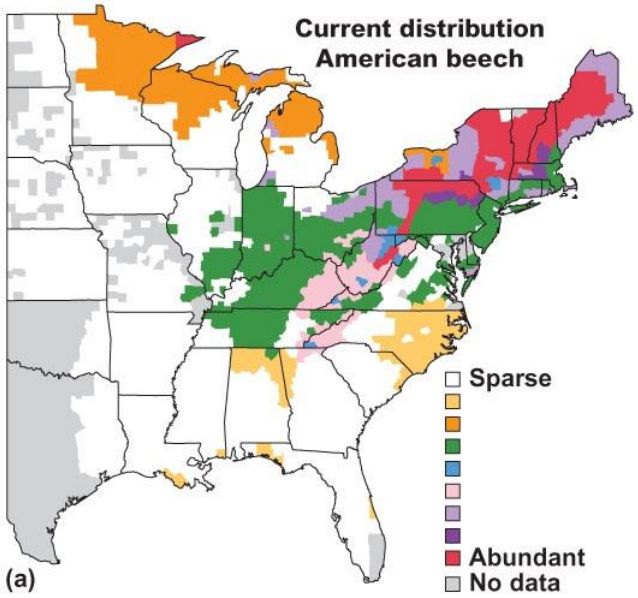
Source: IPCC, 2007.

Predicted global temperature changes with no change in greenhouse gas emissions



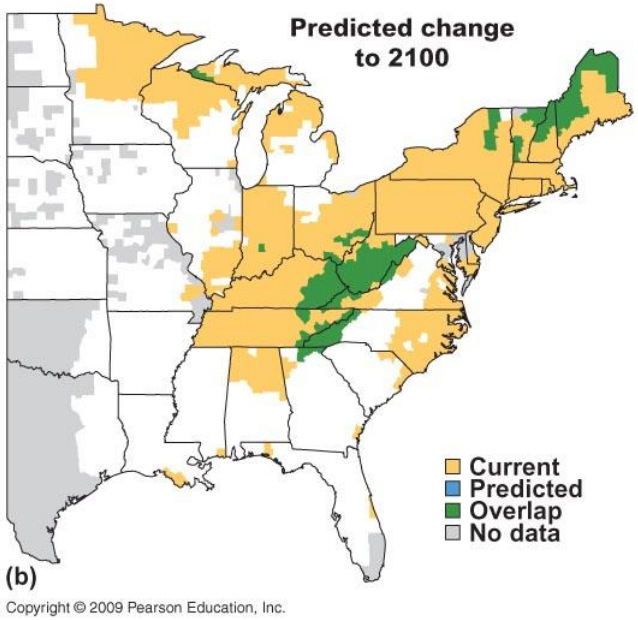
Wheat growing range will shift northward

Today



American beech will shift northward

2100

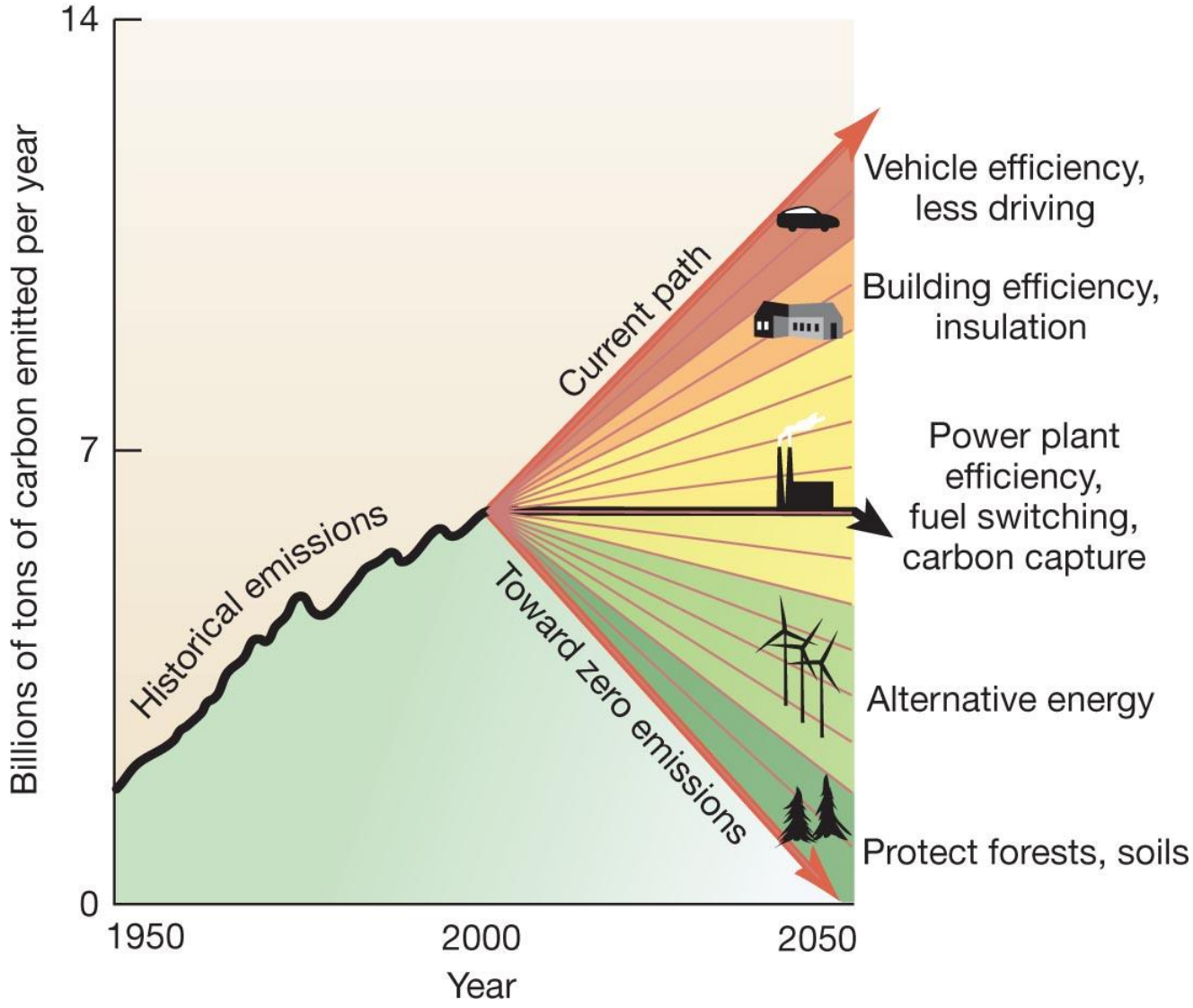


Loss of coastal land areas due to sea level increase

Current and Near-term Solutions

Reduce emissions – alternative energy sources

- distributed power – fuel cells, solar
- expand electric vehicle use
- compact fluorescent and LED lighting
- biogas from organic waste
- increase fuel efficiency of motor vehicles – reduce weight
- concentrated power – wind, waste combustion

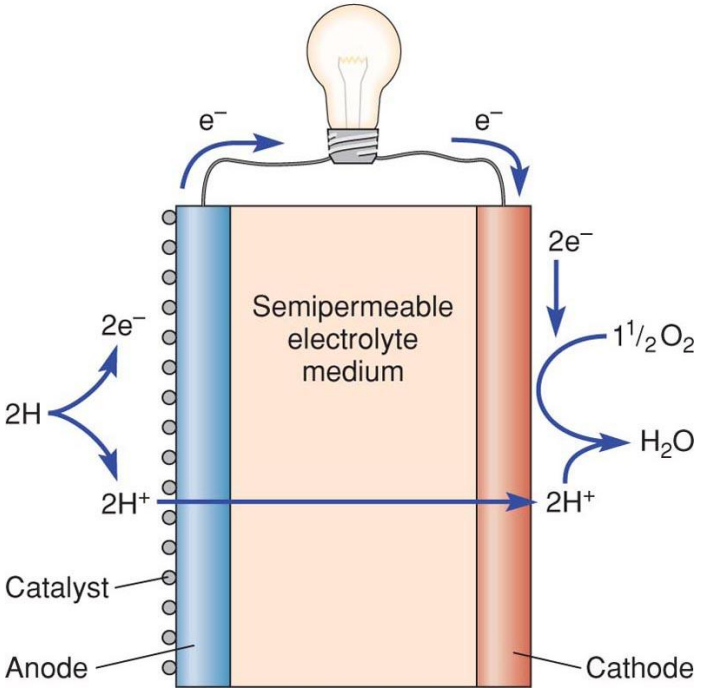


Possible solutions to increases in CO_2 emissions

Distributed Power – Making Electricity Where It Is Used

Fuel cells – available today as backup sources

Solar – electricity, water heating, and cooking



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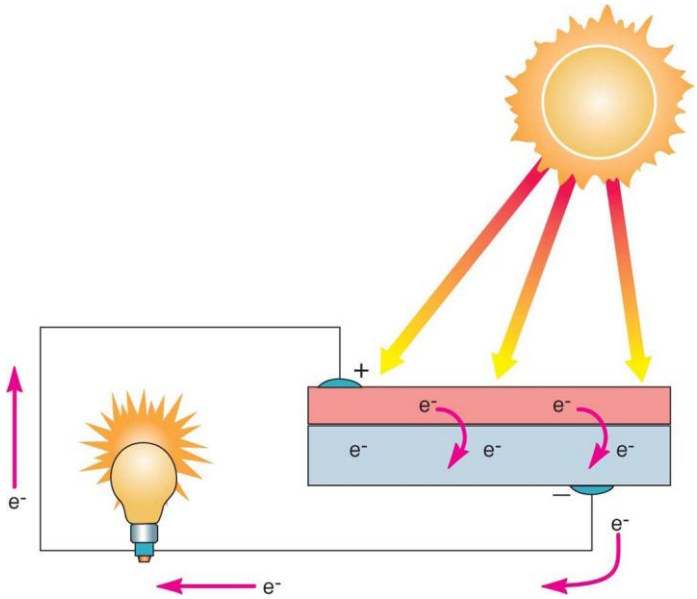
Courtesy of Long Island Power Authority

backup energy supply for a bank!

Fuel Cells – available today as backup sources and primary energy sources

Solar energy can cook – no emissions

© William P. Cunningham



Solar panels can easily power a house

Why not require them on new developments?

Courtesy of National Renewable Energy Laboratory/NREL/PIX

Reva electric car – Bangalore

- small, fast, low emissions

compact fluorescent light – use less energy, but contain mercury

LED light – coming soon

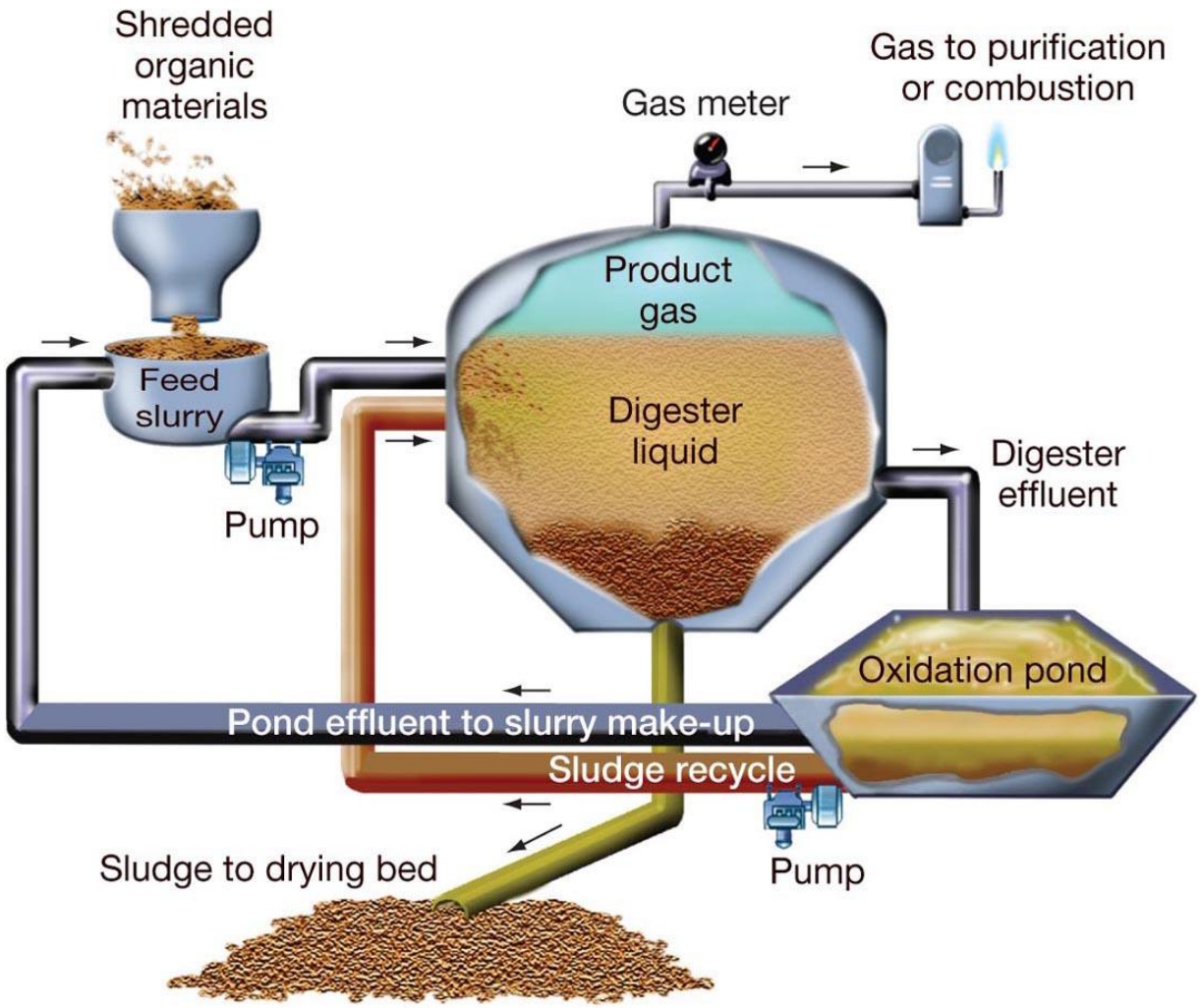
Concentrated Energy Sources

Wind farms

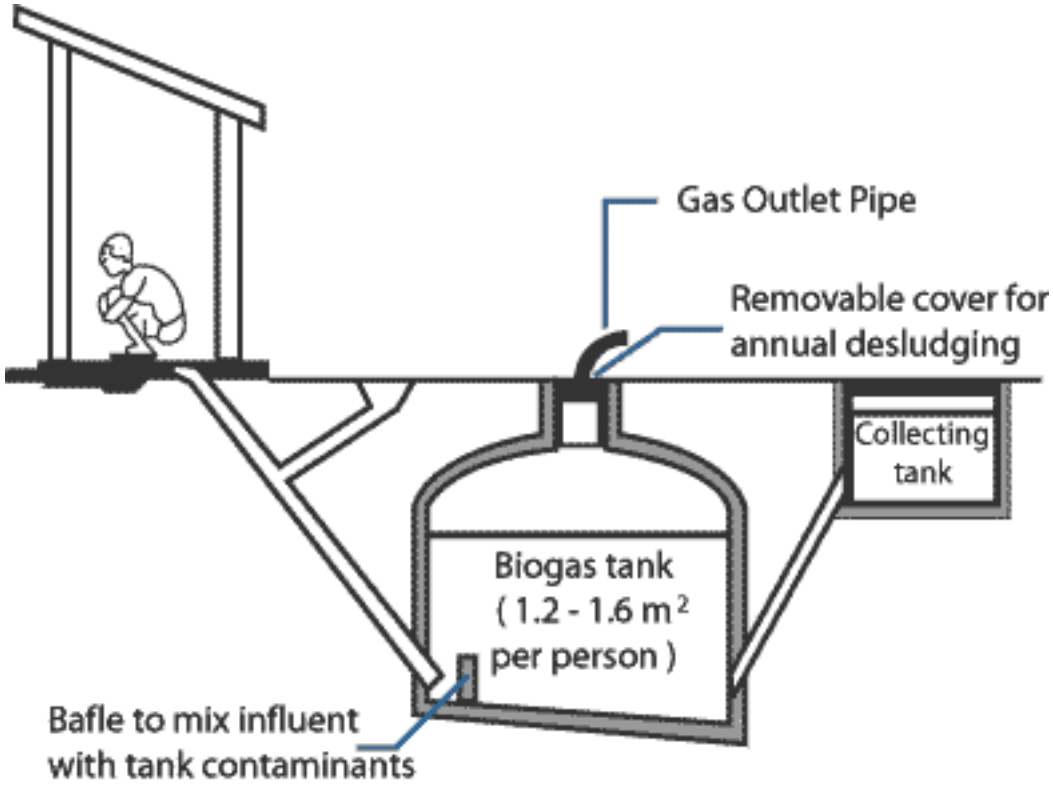
Biomass fueled power plants – increase use of waste biomass as a fuel source

Co-generation using waste heat

Modern wind turbines generate more power with less damage to birds, bats, etc.



Biogas digesters turn organic waste into methane for combustion in cars, trains, and power plants



Biogas digesters come in all sizes... and are “off-the-shelf” technology

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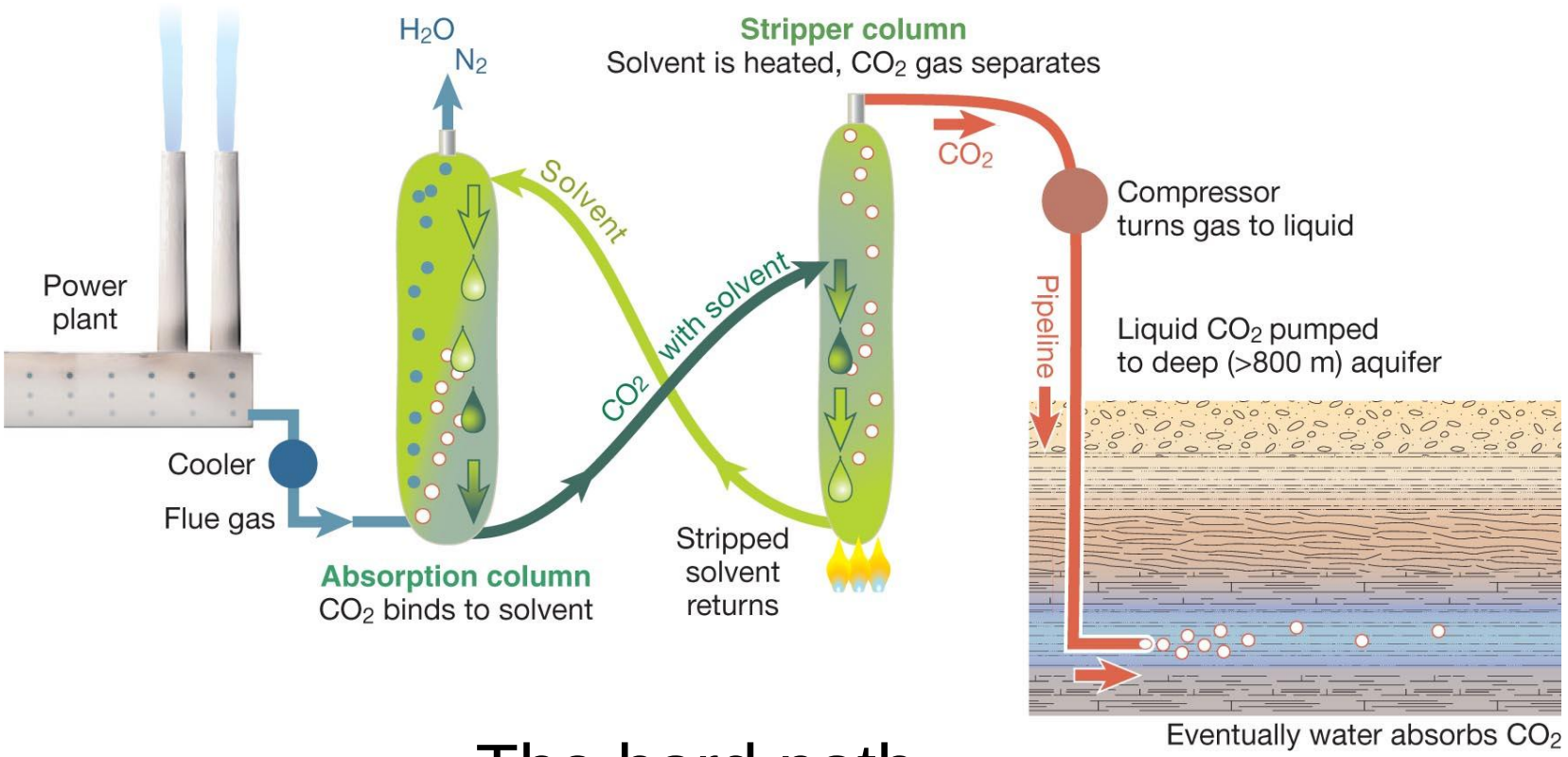
Burning waste biomass has no net increase in CO_2

CO_2 Removal From the Atmosphere

- Increase reforestation efforts
- Green roofs
- CO_2 sequestration

Re-forestation in China – 50 billion trees in 20 years



The hard path...

CO_2 sequestration – possibly a solution in the distant future?

- it would allow continued burning of fossil fuels

Thank You